

## GLOBE Freshwater Ice Phenology Protocols

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The freeze-up and break-up dates of rivers and lakes have been documented throughout the world for centuries. The duration of the ice cover of a freshwater body integrates a number of environmental factors during the ice growth and decay season, particularly the air temperature and snowfall. The inter-annual variability of the freshwater ice cover duration (and ice thickness) is directly affected by these parameters. Furthermore, freshwater ice cover duration can be used as an indicator of climate change. Magnuson et al. (2000) analyzed data from the Northern Hemisphere and found that freeze-up occurs 8.7 days later and break-up occurs 9.8 day earlier than in 1845. This represents a decrease of about 19 days in the ice cover duration which corresponds to a change in mean annual air temperature of about 1.2°C per 100 years.

Monitoring the freeze-up and break-up of local lakes and rivers is relatively straightforward and of significant scientific value in this time of changing environmental conditions. Through the GLOBE Earth System Science Project (ESSP) Seasons and Biomes we have developed a set of freshwater ice phenology protocols that can be performed by upper elementary to high school level students. Using a combination of prescribed digital photographs and a checklist of observations of ice and general environmental conditions, the freeze-up (initial ice formation to 100% ice cover) and break-up (100% bare ice cover to 0% ice cover) are characterized. These observations are made daily. Through these protocols, the students learn science process and inquiry skills by making observations, integrate complementary data sets, and analyze data with various scientific tools and procedures.

These protocols can be used in conjunction with other GLOBE protocols to build an educational program that provides a full appreciation of the relationships between the ice conditions and the forcing environmental conditions (weather based) and an integrated understanding of the fall-winter and winter-spring seasonal transitions (vegetation and fauna based). For example in Alaska, the data acquired using the GLOBE Freshwater Ice Phenology Protocol will complement the snow and ice thickness data acquired by 4-12 grade students and teachers participating in the Alaska Lake Ice and Snow Observatory Network (ALISON, <http://www.gi.alaska.edu/alison/>). Similarly, freshwater ice phenology data will complement vegetation phenology and weather data acquired by GLOBE students in climate change studies in Alaska as well as in other regions of the United States and the world.